

RADIATION STANDARDS FOR YUCCA MOUNTAIN

Statement of

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Good morning, Mr. Chairman and members of the Committee. My name is Robert W. Fri. I am a Visiting Scholar at Resources for the Future, a Washington-based nonprofit organization that aims to improve environmental and natural resource policy-making through objective social science research. I was also the chair of the National Research Council's Committee on Technical Bases for Yucca Mountain Standards.¹ Our committee's report, *Technical Bases for Yucca Mountain Standards*, was issued in 1995. I have been asked to summarize for you the recommendations in that report and to comment particularly on the current status of the health standard for the radioactive waste repository proposed for Yucca Mountain.

As background, the Energy Policy Act of 1992 directed EPA to arrange for an analysis by the National Academy of Sciences (NAS) of the scientific bases for radiation protection standards to be applied at Yucca Mountain. The Act also directed EPA to develop radiation protection standards that were "based upon and consistent with" the National Academy of Sciences' recommendations:

... the Administrator shall, based upon and consistent with the findings and recommendations of the National Academy of Sciences, promulgate, by rule, public health and safety standards for protection of the public from releases from radioactive materials stored or disposed of in the repository at the Yucca Mountain site. Such standards shall prescribe the maximum annual effective dose equivalent to individual members of the public from releases to the accessible environment from radioactive materials stored or disposed of in the repository. (P.L. 102-486, Title VIII, Section 801. 42 U.S.C. Section 10141)

The NAS findings and recommendations to EPA on the technical bases for Yucca Mountain standards were provided in the National Research Council report entitled *Technical Bases for Yucca Mountain Standards*, hereafter referred to as the "TYMS report." This report was authored by a committee of experts that was appointed by the Chairman of the National Research Council. The TYMS committee was disbanded after its report was completed in 1995. Accordingly, I am appearing here today as past chairman of the TYMS committee, not as a representative of Resources for the Future. I will provide you with a summary of the TYMS report's recommendations relevant to the topic of this hearing and will then discuss their relevance to the EPA standard.

I will summarize the TYMS report's recommendations under three headings:

- The elements of the standard itself
- Treatment of human intrusion
- Compliance assessment

¹ The National Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology.

Compliance assessment has proved to be the most difficult of these issues and I will focus my comments on that topic.²

The Elements of the Standard

The TYMS report made five recommendations regarding the elements of the health standard for Yucca Mountain. They are:

1. **THE FORM OF THE STANDARD.** Although the Energy Policy Act stipulated that EPA should develop a standard that prescribes dose equivalents, the TYMS report recommended that EPA develop a standard that sets a limit on the *risk* to individuals of adverse health effects from releases from the repository.
2. **LEVEL OF PROTECTION.** The TYMS report noted that the level of protection was a policy decision to be established through the rulemaking process. Science can provide some guidance in this matter, but in the end the level of protection that the public wants is up to them.
3. **PROTECTION OF THE GENERAL PUBLIC.** The TYMS report concluded that an individual-risk standard would protect the health of the general public, provided that policy makers and the public were prepared to accept that very low radiation doses pose a negligibly small risks.
4. **TECHNOLOGY-BASED STANDARDS.** The TYMS report recommended against imposing repository subsystem performance requirements in the Yucca Mountain standards.
5. **ALARA.**³ The TYMS report noted that there is no scientific basis for incorporating the ALARA principle into the standard.

With the exception of the Committee's preference for a risk-based standard, EPA appears to have generally concurred in these recommendations regarding the elements of the standard. EPA has adopted a dose-based standard, which is functionally equivalent to a risk-based standard only so long as the arithmetic relationship between dose and risk is fixed. Moreover, a dose-based standard is less easily understood by the public than a standard stated in terms of the incremental risk associated with future releases of radiation from the repository.

² The National Research Council report, *Comments on Proposed Radiation Standards for Yucca Mountain by the Board on Radioactive Waste Management*, Washington, D.C., 1999 contains a complete summary of the TYMS report recommendations. Much of the summary material presented here regarding the elements of the standard and the treatment of human intrusion is taken from that report.

³ ALARA, or "As Low As Reasonably Achievable," is usually applied after threshold regulatory limits have been met. Under ALARA, all exposures shall be kept as low as reasonably achievable, social and economic factors being taken into account (e.g., International Commission on Radiological Protection Report ICRP-60, 1991).

Treatment of Human Intrusion

The TYMS report recommended that the standards developed by EPA should require active and passive institutional controls in the near term, should be based on an explicitly assumed intrusion scenario in the long term, and should set limits for the human intrusion scenario that are no more stringent than the undisturbed case. EPA's standard is broadly consistent with this recommendation.

Compliance Assessment

The differences between the standard proposed by EPA and the recommendations of the TYMS committee are greatest in the area of how to assess whether the repository will comply with the radiation standard that EPA sets. And it is on the issue of compliance assessment that the D.C. Circuit Court of Appeals remanded the proposed standard to EPA. I will first review the physical processes that the standard is meant to govern, then compare how the TYMS committee addressed the compliance issue, compare our approach to that of EPA, and finally comment on the decision of the appeals court.

Conceptually, the physical processes involved are relatively straightforward. Radioactive waste is placed in metal canisters and the canisters are buried in Yucca Mountain in a system of tunnels. Over thousands of years, these canisters will corrode and begin to release their waste into the geological formations in which they were buried. Infiltrating water from the surface of Yucca Mountain will carry this waste downward through the rock formations, ultimately reaching the water table. Once it reaches the water table, this radioactive waste will be carried by groundwater away from the Yucca Mountain site. During this whole transport process, the level of radioactivity in the waste slowly declines, although some persists for hundreds of thousands of years.

As the radioactive waste is moved by groundwater away from the site, it can come into contact with human activity. The chief contact is likely to be through the extraction of contaminated groundwater for direct or indirect human consumption. If this occurs, humans could be exposed to radioactivity by drinking this extracted water or eating food irrigated with this water. The objective of compliance assessment is to determine whether this exposure of humans to radioactivity would result in a dose (or risk) that exceeds the EPA standard.

This brief summary of the physical processes by which the public could be exposed to radiation escaping from the repository serves to illustrate the importance of three recommendations made by the TYMS committee regarding compliance assessment.

1. **How Long.** The TYMS report concluded that there is no scientific basis for limiting the compliance assessment period to 10,000 years, as proposed by EPA. That being the case, the committee recommended that compliance assessment be conducted for the time up to which the greatest risk of exposure to radiation from Yucca Mountain occurs, within the limits imposed by the long-term stability of the geologic environment. The report

- concluded that the geological formations at Yucca Mountain were sufficiently stable to permit modeling of physical processes that control movement of radioactive waste from the repository for periods on the order of one million years. It is important to understand that this conclusion does not necessarily suggest that we can predict what will happen one million years from now, or even 10,000 years from now. Rather, the TYMS committee concluded that modeling physical processes for up to about a million years is not appreciably more difficult than doing so for ten thousand years. The longer time horizon provides more time for the radioactive waste released from the repository to migrate to distant locations where it is more likely to come into contact with humans.
2. **EXPOSURE SCENARIOS.** An exposure scenario describes the means by which humans are exposed to the radioactive waste from Yucca Mountain—chiefly through extraction of groundwater. The TYMS report concluded that there is no scientific basis for predicting the societal factors required to establish exposure scenarios and, therefore, the report recommended that such scenarios be established through the rulemaking process. The practical consequence of this recommendation is to rely on knowledge of current human activity around the site rather than to speculate on what people might do in the future.
 3. **WHO IS PROTECTED.** The TYMS report recommended that EPA apply the standards to a *critical group* representative of those individuals in the population who, based on cautious, but reasonable, assumptions, have the highest risk resulting from repository releases. The purpose of this recommendation was to avoid the accumulation of overly conservative assumptions. In particular, Yucca Mountain was selected because of its isolation to reduce the likelihood that some individual would extract groundwater that is contaminated with radioactive waste from Yucca Mountain. The committee concluded that this isolation should be taken into account in compliance assessment, and so recommended that the probability of people being present be taken into account when selecting the critical group.

The inconsistency, if there is one, between the TYMS committee recommendations and the standard that EPA promulgated in 1999 lies in the different treatment of the time horizon of the compliance assessment and the definition of who is to be protected. The TYMS committee elected to carry the time horizon out to the point of greatest risk to the public, which is almost certainly more than ten thousand years. EPA limited its compliance standard to ten thousand years. On the question of who is protected, the committee recommended a probabilistic identification of a critical group that would account for the isolation of the Yucca Mountain site. EPA proposed to protect what it defined as the *Reasonably Maximally Exposed Individual*. This individual was assumed to live above groundwater that contains the highest concentration of radioactive contamination from Yucca Mountain, and eats food and drinks water that contains this contamination. In other words, the Reasonably Maximally Exposed Individual is a deterministic concept; there is no doubt that this person will encounter the most contaminated water from the repository.

These differences can be illustrated in the chart at Figure 1. The vertical axis represents the time horizon of the compliance assessment, and the horizontal axis represents the degree to which the person to be protected is selected on a probabilistic or deterministic basis. As you can see, the TYMS committee and EPA are at diametrically opposite ends of this representation. The TYMS report, in the upper right-hand corner, uses a longer compliance period and a probabilistic exposure scenario. The EPA standard is just the reverse—a short compliance period and a deterministic exposure scenario.

I will conclude my presentation by offering some personal observations on how the revised standard proposed by EPA in 2005 responds to the TYMS report recommendations. The DC appeals court concluded that EPA had not set a standard that was *based upon and consistent with the findings and recommendations of the National Academy of Sciences*, because EPA did not follow the committee's advice on the compliance period. However, in proposing a new standard in response to the court's direction EPA had to deal with the problem that the specification of the time horizon and the selection of the person to be protected are intimately connected.

So, in revising the standard, EPA could have looked at what combination of time horizon and selection of the person to be protected creates a reasonable case that is consistent with the court's opinion. For example, it could have shown that the protection afforded to the public by its remanded standard is functionally equivalent to the recommendations of the TYMS committee, and that there are good policy reasons for using the EPA approach. Or it could have accepted the longer time horizon but selected the individual at risk in a less deterministic way, thus avoiding an overly conservative approach.

It appears, however, that EPA had policy reasons for retaining the Reasonably Maximally Exposed Individual as the definition of the individual at risk. This decision would place the standard in the upper left-hand corner of Figure 1. But that is a place that the TYMS committee specifically did not want to be. We know this because one member of the committee did want to combine a long time horizon with a deterministic selection, a position that he outlined in some detail in the report.

But this position runs the risk of excessive conservatism. As I wrote in response to this committee member's proposal:

“... the standard should avoid ‘... an extreme case defined by unreasonable assumptions regarding factors affecting dose and risk’. ... some members of the committee believe that the approach advocated by [the dissenting member] could become just such an extreme case.” (TYMS report, page 188)

What EPA did to avoid becoming overly conservative, as I interpret the new proposal, is to retain the 10,000 year standard and the Reasonably Maximally Exposed Individual as the person at risk, and to add a post-10,000 year all-pathways standard that applies to the time of peak dose at a period of up to one million years. The numerical value of that added standard is 350 millirem, which is higher than dose allowed for the 10,000 year standard. It is difficult to say whether EPA's proposed standard is consistent with the TYMS report, which only provided risk ranges as starting points for EPA's analysis. I would note, however, that the committee

recognized that EPA properly had considerable discretion in applying policy considerations outside the scope of our study to the development of the health standard for Yucca Mountain.

Thank you for your attention. I would be happy to answer any questions you may have.

	Deterministic Exposure Scenario	Probabilistic Exposure Scenario
Longer Compliance Time	Revised EPA Standard for Yucca Mountain?	TYMS Report
Shorter Compliance Time	1999 EPA Standard for Yucca Mountain	

FIGURE 1: Approaches for setting a radiation standard for Yucca Mountain